Poster #9-43

Space-Based Estimates of Amazon Basin GPP Using Atmospheric Carbonyl Sulfide

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BER Program: TES
Project: University Award

Terrestrial photosynthesis is the fundamental coupling between global cycles of energy, carbon, and water (Figure 1). Photosynthesis is driven by incoming radiation and water availability, modulates atmospheric carbon and in turn releases water vapor that can drive cloud distributions and rainfall. But the most productive region on Earth, the tropical biosphere, remains a critical blind spot in our attempts to understand photosynthesis. Even groundbreaking satellite observations of solar-induced chlorophyll fluorescence (SIF) are largely obscured by the persistence of tropical clouds. What lies beneath these clouds is the central enigma of the carbon cycle.
Here we leverage the temporally and spatially integrative attributes of atmospheric carbonyl sulfide (OCS or COS) to fill the critical gaps left from other regional analysis, creating a necessary and complementary measurement. The atmospheric OCS tracer is related to a temporally and spatially integrated measurement of photosynthesis that is upwind of the OCS measurement. When clouds are present, the ability to accurately measure OCS is lost. However, the photosynthesis signal is preserved in time as the accumulated atmospheric OCS signal. When the clouds clear or when the air parcel is transported by wind and convection away from the clouds, the subsequent atmospheric OCS measurement provides an integral view of the photosynthesis fluxes that were upwind of where the OCS measurement was made. Thus, the atmospheric OCS variation provides an archive of the photosynthesis activity that can be collected by satellites at times and locations that are not contaminated by clouds. This unique temporal integration of the OCS method could have a transformative effect on our ability to uncover the mysteries of photosynthesis in the tropics.

We inferred regional GPP estimates from space-based observations of upper tropospheric atmospheric OCS (Figure 1). The analysis was based on global atmospheric chemical transport simulations (GEOSCHEM) that were linked to global ecosystem flux estimates (SiB). The OCS satellite constraint on these simulations resulted in a measurement-based estimates of Amazon basin-wide GPP that overlaps with the range of GPP estimates reported in previous bottom-up and ecosystem modeling studies, building confidence in this new independent tracer technique.